All-Pay Auctions vs. Lotteries as Self-Financing Fundraising Mechanisms: Theory and Evidence*

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Abstract

We study two self-financing, fixed-prize based mechanisms for funding public goods: an all-pay auction and a lottery. In our setting, the public good is provided only if the participants' contributions are greater than the fixed-prize value; otherwise contributions are refunded. We prove that in this setting, lotteries can outperform all-pay auctions in terms of expected public good provision. Specifically we state conditions under which the all-pay auction mechansim generates zero public good provision, while the lottery mechanism generates positive public good provision. We test these predictions in a laboratory experiment where we vary the number of participants, the marginal per capita return (mpcr) on the public good, and the mechanism for awarding the prize either a lottery or all-pay auction. Consistent with the theory, we find that the mpcr matters for contribution amounts under the lottery mechanism. However, inconsistent with the theory bids are always significantly higher than predicted and there is no significant difference in public good contributions under either mechanism.

Keywords: All-pay auction, lottery, public goods, prize-based mechanisms, fundraising, experiment.
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1 Introduction

How should a public good be financed? After Morgan (2000) theoretically showed that fixed-prize charitable lotteries yield greater contributions to a public good than does the voluntary contribution mechanism (VCM), several papers have sought to confirm his findings in the laboratory, see, e.g., Morgan and Sefton (2000), Lange et al. (2007), Orzen (2008), Schram and Onderstal (2009), and Corazzini et al. (2009) among others. Moreover, several studies, see Orzen (2008), Schram and Onderstal (2009), and Corazzini et al. (2009) compare public good provision under fixed-prize lotteries and various types of fixed-prize auctions. A common finding in this literature is that fixed-prize fund-raising mechanisms greatly outperform the VCM in term of raising funds, though the various studies do not all agree on which fixed-prize mechanism works best.

In this paper, we also investigate the performance of two fixed-prize fund-raising mechanisms - a lottery and an all-pay auction but we do so in an environment that differs in one important respect from the environments that have been typically studied in this literature. The key difference is that we require the fixed prize to be financed by the fund-raising mechanism itself. If the mechanism does not raise funds sufficient to cover the amount of the fixed prize – if the mechanism is not "self-financing" - then the prize is not awarded and all contributions are refunded. Such "provisional" mechanisms are attractive as they are risk-free as compared with "exogenous" or "non-provisional" fixed-prize mechanisms. If a fund-raiser has to first buy a prize good (e.g. a car) or guarantee a fixed monetary prize amount irrespective of the subsequent contribution decisions of participants, then if total contributions turn out to be less than the value of that fixed prize, the fund-raiser's net return is negative. However, under a self-financed (or provisional) fixed-prize mechanism, the fund-raiser's net return is always non-negative.

Indeed, we do not observe non-provisional fixed-prize charitable fund-raising mechanisms in the field (unless the prize itself is a charitable donation). Prize-based charitable fund-raising mechanisms are typically risk-free for the fund-raiser. Many have the structure of parimutuel -betting systems in that the prize amount is endogenously determined and equal to some fixed percentage of the total amount raised by the mechanism (typically a lottery). For example, in the U.S. many small charitable organizations sell tickets to "50-50" lotteries where the endogenously determined monetary prize is 50 percent of the total value of all tickets sold; the remaining 50 percent goes to the charity. Similarly (though in a non-public-good setting), Groupon and other social e–commerce websites offer the prize of discounted merchandise if a fixed and known number of buyers commit to buying a seller's good or service at a discounted price, with payments refunded if the threshold number of buyers is not met.

However, as Morgan (2000) showed, pure pari-mutuel prized-based lottery mechanisms have the disadvantage that they generate contribution incentives that are equivalent to those of the VCM, that is, the equilibrium public good provision under a parimutuel-prize lottery mechanism is the same as under the VCM. For this reason we focus on provisional but fixed-prize fund-raising mechanisms.

In that setting we show that the use of a lottery mechanism to determine the prize winner should strictly outperform the use of an all-pay auction mechanism to determine the prize winner. In particular, we demonstrate that if endowments are sufficiently large relative to the provisional, fixed-prize level, then the unique equilibrium under the all-pay auction mechanism results in zero public good provision. This result stands in sharp contrast to the existing literature on all-pay auctions as fund-raising mechanisms where the fixed prize is independent of participants' contributions (i.e. is non-provisional). In that literature (discussed in section 2) the all-pay auction is predicted to generate more public good provision than the lottery. The key reason for our different finding is our assumption that the fixed-prize is only provisionally provided.

For some intuition, consider a setting where a charity offers a prize and there are n participants. If the value of the prize, V, is exogenously given (i.e., it is not provisional on contributions equalling or exceeding V) then, if an all-pay auction is used to award the prize there will typically exist a symmetric mixed strategy equilibrium in which players submit bids from a bounded, continuous interval from 0 on up to some upper bound. In this symmetric mixed strategy equilibrium players are indifferent among all bids in the interval. In particular, the expected value of a "small" bid – a bid between 0 and V/n– is equal to the expected value of a bid of 0; the small bid has a small chance of winning the non-provisional, fixed prize but it also involves a small cost (the bid amount) which is always paid in an all-pay auction. Now suppose that there exists a symmetric mixed strategy equilibrium in the case where the prize is provisional on contributions equalling or exceeding the value of the prize, V. The structure of such an equilibrium would be the same as in the non-provisional prize case – there would be a bounded continuous interval of bids over which players are indifferent. In the case of a provisional prize however, a bid of zero will weakly dominate any small bid. If a player wins with a small bid, the prize is not provided since, from our definition of a small bid, the provisional threshold will not have been reached. If a player loses with a small bid, he has to pay the small bid and is worse off relative to a bid of zero. Suppose next that participants consider bidding on any bounded continuous interval above zero. In that setting, bids at the left boundary always lose under an all-pay auction (but not under a lottery!) and such bids are costly to the bidder as they are strictly greater than zero. Essentially one cannot find a left boundary such that individuals are indifferent among bids over some bounded continuous interval that excludes zero as would be required in any symmetric mixed strategy equilibrium.[1] As we show, if the endowment is sufficiently large relative to the prize, then the unique symmetric equilibrium prediction calls for zero contributions by all participants in the all-pay charity auction with a provisional prize. Essentially, the use of the all-pay auction mechanism to award a provisional but fixed prize transforms the game so that its incentives are similar to those of the VCM where the dominant, equilibrium strategy is for all to contribute nothing.

As Morgan (2000) showed, the use of a lottery mechanism to award a provisional

[1] This outcome is similar in certain respects to Shubik's (1971) dollar auction, where bidders escalate their efforts to outbid each other.

but fixed prize does not have this same implication. Thus we argue that lotteries should be preferable to all-pay auctions as fund-raising mechanisms in the provisional but fixed-prize environment that we study. More generally our finding may explain why lotteries are the more commonly observed mechanism for generating public good contributions. This observation is confirmed in Carpenter, Holmes and Matthews (2008) who show that in a field experiment, participants prefer to participate in lotteries as opposed to all-pay auctions.

In addition to pointing out theoretical differences between self-financed (provisional) and exogenous fixed-prize fund-raising mechanisms, we have also run a series of experiments to test the theory we have developed for provisional, fixed-prize fund-raising mechanisms. We use a $2 \times 2 \times 2$ experimental design where the treatment variables are: (1) all-pay auction or lottery rules to determine the prize winner; (2) group size $n = 2$ or $n = 10$ and (3) marginal per capita return (*mpcr*) on the public good, $\beta = .25$ or $\beta = .75$. Another novelty of our study over existing studies is that we vary both the group size and the mpcr, in addition to comparing two different fund-raising mechanisms.

Our theoretical findings indicate under certain conditions, public good provision should be greater under the provisional, fixed-prize lottery mechanism than under the corresponding all-pay auction mechanism for the same number of participants, n, and marginal per capita return (*mpcr*) on the public good. In fact, for the parameterization of the model environment that we study in the experiment, individual contributions and public good provision should always be zero under the provisional fixed-prize all-pay auction mechanism, whereas they can be positive under the provisional, fixed-prize lottery mechanism. Specifically, in the environment we study, for low *mpcr* and n, our theory predicts *no* public good provision under the provisional, fixed-prize lottery mechanism - the same prediction for the provisional, fixed-prize all pay auction mechanism. However, fixing n, individual contributions and public good provision are predicted to increase with the *mpcr* under the lottery mechanism. Similarly, under the provisional fixed-prize lottery mechanism, for fixed *mpcr*, public good provision is predicted to increase with the group size n, though individual contributions are predicted to decrease with the group size, n. By contrast, these variations in n and the *mpcr* are predicted to have *no* impact on contributions or public good provision under the provisional, fixed-prize all-pay auction mechanism which always predicts zero contributions in the environment we study. These rather stark theoretical predictions are tested in a laboratory experiment where, as in the theory we examine, we keep individual endowments and the prize amount fixed across all treatments.

Our experiment has yielded the following findings. First, consistent with the theory, contributions to the public good increase with the *mpcr* under the provisional fixed-prize lottery mechanism. However, opposite to the theory, contributions to the public good increase with the *mpcr* in the all-pay auction mechanism and, for a given *mpcr*, the average amount bid by each participant increases with increases in the total number of participants, n, under both prize-based mechanisms, even though the prize amount is fixed and therefore does not vary with n. Consequently, public good provision also increases with n, a finding that *is* consistent with theoretical predictions for the lottery mechanism but is *in*consistent with theoretical predictions for the all-pay auction mechanism; in the latter, for a given *mpcr*, the expected public good provision should remain at zero level as n increases. Further, for most values of n and the *mpcr* considered in this experiment, the amounts bid are significantly greater than theoretical predictions, though there is some decline as subjects gain experience. Finally, and perhaps most importantly, for any given *mpcr* and n, we find *no significant difference* in the amount of public good provision under either mechanism.

The rest of this paper is organized as follows. Section 2 situates our paper in the theoretical and experimental literature. Section 3 presents the theory. Section 4 describes the experimental design and section 5 reports our main experimental findings. Section 6 concludes. The proofs of Propositions 1 and 2 are provided in Appendix A and sample experimental instructions are provided in Appendix B.

2 Related Literature

There are several prior theoretical and experimental studies of lotteries and/or auctions as fund-raising mechanisms that we build upon or that are related to this paper. As previously noted, Morgan (2000) initiated the literature by exploring the performance of provisional, fixed-prize and pari-mutuel lottery mechanisms and he showed that the former would generally outperform the VCM in public good provision. Morgan and Sefton (2000) provide experimental evidence in support of Morgan's (2000) theoretical predictions. Importantly, Morgan and Sefton (2000) adopt an experimental design where the fixed prize that is offered is *not* provisional on contributions being sufficient to cover that prize amount. They note (in footnote 6, p. 787) that "while this assumption is patently unrealistic, the results are unchanged by more realistically allowing the raffle [lottery] to be called off and the bets returned in the event that insufficient wagers are made." That statement is true in the case of the lottery mechanism (as Morgan (2000) himself showed) but as we show in this paper it is not true under the all-pay auction mechanism. Nevertheless it seems that the subsequent theoretical and experimental literature on prize-based fund-raising mechanisms has followed Morgan and Sefton's (2000) lead in assuming non-provisional fixed prizes in evaluating other prized-based mechanisms such as the winner-pay and the all-pay auction mechanisms. This is somewhat surprising as it is both theoretically and experimentally simple and "more realistic" to make the awarding of the fixed prize provisional on contribution levels covering the prize amount.

Goeree et al. (2005) compared lotteries with auctions in the case where bidders have *independent private values* for a prize object and where all proceeds from the fund-raising mechanism accrue to a public good (charity) for which all bidders derive some benefit. In their setting, the prize object is exogenously given (e.g., a donated good) and not provisional on the amounts bid.[2] They observe that while lotteries may

[2] The assumption of an exogenously given prize (auction object) that is already in the possesion of the charity (seller) follows the tradition in the auction literature. However, in a charity auction

be preferred to *winner-pay* auctions, lotteries are always inefficient and may generate less revenue when compared with kth-price *all–pay* auctions, where the winner is the individual submitting the highest bid, the k highest bidders pay the kth highest bid and all other (lower) bidders pay their bids. Goeree et al. provide conditions under which the lowest-price all pay auction is the optimal fund-raising mechanism in that it generates the most revenue assures that the prize is awarded to the individual with the highest valuation. Schram and Onderstal (2009) experimentally compare lotteries, winner-pay and all-pay auctions where, as in Goeree et al. (2005), participants have independent private values for a non-provisional prize good. Schram and Onderstal report that all-pay auctions outperform the other two mechanisms in charitable fund-raising. By contrast, our paper compares lotteries and first-price all–pay auctions under *complete* information, where all participants are certain of the value that others assign to winning the provisional fixed prize. This setting, while simple, allows us to derive equilibrium predictions for bidding strategies and expected public good provision levels as functions of the number of bidders n and the marginal per capita return on the public good, β.

Orzen (2008) theoretically and experimentally compares the VCM with lotteries and all-pay auctions. His theoretical findings for the all-pay auction are different from ours as he assumes an non-provisional fixed prize. Moreover, the focus of his experiment is also different. He chooses $\beta = 0.5$ and $n = 4$ and compares how different fund-raising mechanisms perform for those parameters. Like us, he finds no significant difference between lotteries and all-pay auctions for the parameterization that he studies. Corazzini et al. (2009) also compare the VCM with lotteries and all-pay auctions when $\beta = 0.5$ and $n = 4$, but they are more interested in the effect of heterogeneity in individual endowments. They report that in their setting contributions are significantly higher under the non-provisional fixed-prize lottery than under the non-provisional fixed-prize all-pay auction.

The importance of making the prize provisional is demonstrated by the findings of Landry et al. (2006) and Lange et al. (2007). In a field experiment, Landry et al. (2006) report that individuals donations are less than the non-provisional fixed-prize value. A similar finding is reported in Lange et al. (2007) who use $\beta = 0.3$ in their experiments. They find that under a non-provisional fixed-prize lottery mechanism, total contributions were insufficient to finance the prize (total contributions were around one-half of the prize value). These findings point to the importance of considering provisional fixed-prize mechanisms. Indeed, the main difference in our experimental design from all prior experimental studies is that we award the fixed prize only if contributions to the public good equal or exceed the amount of the fixed prize.

Among other related papers, Davis et al. (2006), compare lotteries to English (winner-pay) auctions. They find that lotteries generally outperform English auctions in public good provision despite the fact that revenues are predicted to be the same under these two mechanisms. Gneezy and Smorodinsky (2006) consider all-pay auctions without a public good but with a prize of common value as in our design.

this assumption is not necessarily appropriate, for instance, if the charity has buy the prize itself.

They report (as we do) that subjects over-bid and that the auctioneer's revenues are two to three times greater than the value of the prize, even after the auction was repeated several times.

3 Theory

Consider how different n-player, fixed-prize mechanisms affect public good provision. It is a common practice in the literature to assume that the prize, V, is given to a winner whether or not the total contributions exceed the prize value. Formally, in this "exogenous" prize case, player i maximizes her expected payoff, which is given by:

$$u_i\left(x_i, x_{-i}; n, \beta, M\right) = \left(e - x_i\right) + \beta \left(\sum_{j=1}^{n} x_j - V\right) + M\left(x_i, x_{-i}; n\right) V, \tag{1}$$

by choosing her contribution level $x_i \leq e$, where e is the player's endowment, β is the marginal per capita return on the public good and $V > 0$ is the fixed-prize amount awarded to the winner under the mechanism M which is either a lottery or an all-pay auction. We will call problem (1) the exogenously given prize mechanism.

Consider, next the self-financing, provisional prized-based mechanism that is the focus of this paper. We assume that player i maximizes her expected payoff which is given by:

$$\pi_i\left(x_i, x_{-i}; n, \beta, M\right) =$$
$$\begin{cases} \left(e - x_i\right) + \beta\left(\sum_{j=1}^{n} x_j - V\right) + M\left(x_i, x_{-i}; n\right) V, & \text{if } \sum_{j=1}^{n} x_j \geq V, \\ e, & \text{if } \sum_{j=1}^{n} x_j < V, \end{cases} \tag{2}$$

by choosing her contribution level $x_i \leq e$, where e is the player's endowment, and V is the fixed-prize amount provisionally awarded to the winner under the self-financing mechanism M. Note that the threshold level for public good provision is V. If this threshold level is not reached, then the fixed prize amount V is not awarded and all contributions are refunded so that each player's payoff is equal to her endowment, e. If the threshold level is reached, $\sum_{j=1}^{n} x_j \geq V$, then the prize, V, is financed first and awarded to the winner and the remaining amount, $\left(\sum_{j=1}^{n} x_j - V\right)$, goes toward public good provision. We will call problem (2) the self-financed provisional prize mechanism. Note that the only difference between the two settings - our (2) and the standard (1) - is the conditional public good provision in our case (2). We describe and compare the equilibrium predictions for lotteries and all-pay auctions under the two settings (2) and (1) in the next two sections.

3.1 Lottery

If the mechanism is a lottery, then (1) becomes

$$u_i\left(x_i, x_{-i}; n, \beta, \text{Lottery}\right) =$$

$$(e - x_i) + \beta \left(\sum_{j=1}^{n} x_j \right) + \left(\frac{x_i}{\sum_{j=1}^{n} x_j} \right) V. \tag{3}$$

It is well-known - see Morgan and Sefton (2000) and Orzen (2008) - that an n-player public good game with an exogenously given lottery prize has a symmetric pure-strategy equilibrium where each player spends

$$x^* = \min \left\{ \frac{n-1}{n^2} \frac{V}{1-\beta}, e \right\}, \tag{4}$$

and public good provision is equal to

$$G = nx^* = \min \left\{ \frac{n-1}{n} \frac{V}{1-\beta}, ne \right\}.$$

Now consider the self-financing provisional lottery mechanism. In that case, (2) becomes

$$\pi_i \left(x_i, x_{-i}; n, \beta, \text{Lottery} \right) =$$
$$\begin{cases} (e - x_i) + \beta \left(\sum_{j=1}^{n} x_j - V \right) + \left(\frac{x_i}{\sum_{j=1}^{n} x_j} \right) V, & \text{if } \sum_{j=1}^{n} x_j \geq V, \\ e, & \text{if } \sum_{j=1}^{n} x_j < V. \end{cases} \tag{5}$$

Note that it is efficient to provide public good if

$$\beta n \geq 1. \tag{6}$$

We restrict attention to symmetric equilibria and obtain the following result.

Proposition 1 *Consider the self-financing provisional lottery mechanism. Suppose that the efficiency condition* (6) *and the endowment condition:*

$$\frac{V}{n} \leq e \tag{7}$$

both hold. Then, each player spends

$$x^* = \min \left\{ \frac{(n-1)}{n^2} \frac{V}{(1-\beta)}, e \right\} \tag{8}$$

in the symmetric equilibrium.
If either the efficiency condition (6) *or the endowment condition* (7) *do not hold, then there are multiple symmetric equilibria* $(t, ..., t)$ *where each player spends* $t \in [0, \min \{V/n, e\})$ *and the public good is not provided.*
Public good provision is:

$$\widetilde{G} = nx^* - V = \begin{cases} \min \left\{ \frac{(\beta n - 1)}{n(1-\beta)} V, ne - V \right\}, & \textit{if } \beta n \geq 1 \textit{ and } e \geq \frac{V}{n}, \\ 0, & \textit{if } \beta n < 1 \textit{ or } e < \frac{V}{n}. \end{cases} \tag{9}$$

Proof. See Appendix A.

It is interesting to note that whether the prize is self-financed or exogenously given, the equilibrium bid prediction is the same provided that the efficiency condition (6) and the endowment condition (7) both hold. Of course, a difference is that the actual amount of public good provided under the self-financed prize-based lottery mechanism is lower than under the exogenous prize lottery mechanism by the amount of the prize, V. From (9) we see that in the efficient case, public good provision is increasing in n and β. However, in the inefficient case, where condition (6) does not hold, the public good is not provided under the self-financed prize-based lottery mechanism though it would be provided if the prize were exogenously given. This difference is intuitive. If the prize is exogenously given, then players can not only win the prize, as they do in the regular lottery, but they can also receive benefits from the public good. As a result, players find it optimal to bid positive amounts and the public good is provided. However, if the prize is self-financed, then total spending has to be high enough to finance the prize which can only happen if it is efficient to provide the public good in the first place (i.e., if equation (6) holds). Note that the endowment plays an important role in the self-financing mechanism: the endowment has to be big enough to allow players to finance the prize. The endowment size is not important in the case of an exogenously given prize.

3.2 All-Pay Auction

If the mechanism M is an all-pay auction, then (1) becomes

$$\pi_i\left(b_i, b_{-i}; n, \beta, \text{Auction}\right) =$$
$$\begin{cases} V + (e - b_i) + \beta\left(\sum_{j=1}^{n} b_j\right), & \text{if } b_i > b_j \text{ for any } j \neq i, \\ \frac{V}{K} + (e - b_i) + \beta\left(\sum_{j=1}^{n} b_j\right), & \text{if } i \text{ ties } (K-1) \text{ others for high bid}, \\ (e - b_i) + \beta\left(\sum_{j=1}^{n} b_j\right), & \text{if } b_i < b_j \text{ for some } j \neq i. \end{cases} \tag{10}$$

Orzen (2008) proves[3] that if

$$e \leq \frac{V}{(1-\beta)\,n}, \tag{11}$$

then there exists a symmetric pure-strategy equilibrium where each player bids his entire endowment e. He also demonstrates that if

$$0 < \frac{V}{(1-\beta)} \leq e, \tag{12}$$

then there exists a symmetric mixed-strategy equilibrium where each player bids in the interval $\left[0, \frac{V}{1-\beta}\right]$ according to the following distribution function:

$$F\left(b\right) = \left((1-\beta)\,\frac{b}{V}\right)^{\frac{1}{n-1}}. \tag{13}$$

[3]We obtained the same results before running our experiments. Preparing a final draft of our paper, we discovered Orzen's (2008) paper.

Note that the expected public good provision is

$$EG = n \int_0^{\frac{V}{1-\beta}} b dF(b) = \frac{V}{1-\beta}.$$

Now consider the self-financing provisional all-pay auction mechanism. In that case, (2) becomes

$$\pi_i(b_i, b_{-i}; n, \beta, \text{Auction}) = \tag{14}$$
$$\begin{cases} V + (e - b_i) + \beta\left(\sum_{j=1}^n b_j - V\right), & \text{if } b_i > b_j \text{ for any } j \neq i \text{ and } \sum_{j=1}^n b_j \geq V, \\ \frac{V}{K} + (e - b_i) + \beta\left(\sum_{j=1}^n b_j - V\right), & \text{if } i \text{ ties } (K-1) \text{ others for high bid and } \sum_{j=1}^n b_j \geq V, \\ (e - b_i) + \beta\left(\sum_{j=1}^n b_j - V\right), & \text{if } b_i < b_j \text{ for some } j \neq i \text{ and } \sum_{j=1}^n b_j \geq V, \\ e, & \text{if } \sum_{j=1}^n b_j < V. \end{cases}$$

Restricting attention to symmetric equilibria, we obtain the following result.

Proposition 2 *Suppose that efficiency condition* (6) *and the endowment condition:*

$$\frac{V}{n} \leq e \leq \frac{V}{(1-\beta)n} \tag{15}$$

both hold. Then, there exists a unique symmetric pure-strategy equilibrium where each player bids his entire endowment, $b^* = e$*, and the public good is provided under the all-pay auction game.*
If either condition (6) *or condition* (15) *do not hold, then there exists a unique symmetric pure-strategy equilibrium where each player bids zero and the public good is not provided.*
The public good provision is

$$\widetilde{G} = \begin{cases} ne - V, & \text{if } \beta n \geq 1 \text{ and } \frac{V}{n} \leq e \leq \frac{V}{(1-\beta)n}, \\ 0, & \text{if } \beta n < 1 \text{ or } 0 < e < \frac{V}{n} \text{ or } e > \frac{V}{(1-\beta)n}. \end{cases} \tag{16}$$

Proof. See Appendix A.

First, notice that under the self-financing, provisional all-pay auction, the symmetric equilibrium is always in pure strategies, which is a surprising result for an all-pay auction mechanism. Second, we show that the public good can only be provided in the efficient case ($\beta n \geq 1$) as was also the case for the self-financed, prize-based lottery mechanism. Third, for there to be provision of the public good, the endowment condition (15) must be satisfied. Notice that our endowment condition (15) is a modified version of the endowment condition (11) for the exogenously given prize-based all-pay auction mechanism that has been adjusted for self-financing. This endowment condition is very intuitive. If the endowment is very small relative to the prize, i.e., $e < \frac{V}{n}$, then players do not have enough resources to finance the prize and so incentives approximate those of a pure voluntary contribution game. For a small interior range of endowment values the public good is provided. Finally, if the endowment is very large relative to the prize - the case we study in our experiment where $e > \frac{V}{(1-\beta)n}$, then the prize has almost no value to the players and incentives again approximate those of a pure voluntary contribution public good game where the only equilibrium is to contribute nothing. Finally, note that the equilibrium prediction is very different if the prize is self-financed or exogenously given. For example, in the inefficient case, condition (6) does not hold, the public good is never provided under the self-financed prize-based mechanism but might be provided if the prize were exogenously given.

The provision of the public good under the two self-financing provisional prize mechanisms as a function of βn and e is illustrated in Figure 1. Our experimental design involves a choice for $e > \frac{V}{(1-\beta)n}$ so that only the lottery mechanism is predicted to yield provision of the public good, and only in the case where $\beta n > 1$ (corresponding to region **B** of Figure 1.

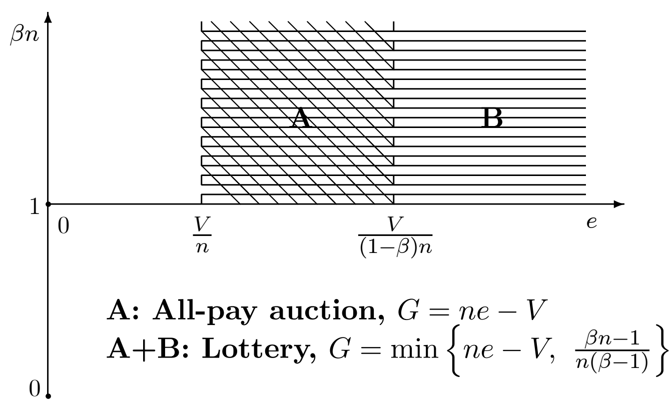

Figure 1: Parameter Regions with Positive Public Good Provision Under the Two Self-Financing Prize-Based Mechanisms

4 Experimental Design and Predictions

In our experiment the prize is always provisional and must be financed by subject contributions. Thus, the payoff function for each subject i is given by equation (2). We adopt a $2 \times 2 \times 2$ experimental design where the treatment variables are: (1) the mechanism, M, either the all-pay auction or lottery rules determine the prize winner; (2) group size $n = 2$ or $n = 10$ and (3) the marginal per capita return (mpcr) on the public good, $\beta = .25$ or $\beta = .75$. All other parameters, i.e., the prize value of $V = 100$ and the endowment of $e = 400$ are kept fixed across all of our experimental sessions.

Our parameterization corresponds to the efficient case, where condition (6) holds. We chose to set $e = 4V$ as we think it is realistic to assume that in charity fund-drives, the value of the prize offered is considerably less than any single participant's endowment. Importantly, this choice for e ensures that we always have a unique pure strategy equilibrium prediction under both the lottery and the all-pay auction self-financed prize-based mechanisms; with this choice for e and for all of our choices for n and β, condition (15) does not hold; instead it is the case that e is always greater than $\frac{V}{(1-\beta)n}$. Finally, we chose values for β and n that are found in the existing literature and that allow us to evaluate some of the comparative static implications of the (lottery) theory.[4]

Given our parameter choices, the symmetric Nash equilibrium predictions for our experimental design are given in Table 1. Notice that for the all-pay auction case, the predicted bid and public good provision level is always zero regardless of treatment values for n and β. As noted above, this prediction arises because condition (15) does not hold in our environment.

	Lottery		All-Pay Auction	
$\beta = .25$	$x^* = \frac{n-1}{n^2}\frac{V}{1-\beta}$	$G = \max\left\{\frac{\beta-\frac{1}{n}}{1-\beta}V, 0\right\}$	$x^* = 0$	$G = 0$
$n = 2$	$\frac{100}{3}$	0	0	0
$n = 10$	12	20	0	0
$\beta = .75$	$x^* = \frac{n-1}{n^2}\frac{V}{1-\beta}$	$G = \max\left\{\frac{\beta-\frac{1}{n}}{1-\beta}V,\ 0\right\}$	$x^* = 0$	$G = 0$
$n = 2$	100	100	0	0
$n = 10$	36	260	0	0

Table 1: Equilibrium predictions under the provisional prize model (2)

It is instructive to compare the equilibrium predictions for the model we study with the non-provisional model where the fixed prize is exogenously given (model (1)). Table 2 provides these predictions. In the latter case, the all-pay auction is predicted to result in positive bids and public good provision and at levels that in expectation exceed the bids and public good provision generated by the lottery mechanism.

	Lottery		All-Pay Auction	
$\beta = .25$	$x^* = \frac{n-1}{n^2}\frac{V}{1-\beta}$	$G = \max\left\{\frac{\beta-\frac{1}{n}}{1-\beta}V, 0\right\}$	$F(b) = \left((1-\beta)\frac{b}{V}\right)^{\frac{1}{n-1}}$	$G = \frac{\beta}{1-\beta}V$
$n = 2$	$\frac{100}{3}$	0	$\left(\frac{3b}{400}\right)$	$\frac{100}{3}$
$n = 10$	12	20	$\left(\frac{3b}{400}\right)^{\frac{1}{9}}$	$\frac{100}{3}$
$\beta = .75$	$x^* = \frac{n-1}{n^2}\frac{V}{1-\beta}$	$G = \max\left\{\frac{\beta-\frac{1}{n}}{1-\beta}V,\ 0\right\}$	$F(b) = \left((1-\beta)\frac{b}{V}\right)^{\frac{1}{n-1}}$	$G = \frac{\beta}{1-\beta}V$
$n = 2$	100	100	$\left(\frac{b}{400}\right)$	300
$n = 10$	36	260	$\left(\frac{b}{400}\right)^{\frac{1}{9}}$	300

Table 2: Equilibrium predictions under the non-provisional, exogenous prize model (1)

[4]For instance, Isaac et. al. (1984) study a VCM using a 2x2 design with $n = 4$ or 10 and $\beta = .3$ or .75.

We report data from 16 experimental sessions, each involving 20 subjects, a total of 320 subjects. Each session involves a within-subject design where either the all-pay auction mechanism or the lottery mechanism was used to determine the prize winner in each group of size $n = 2$ or 10 over the first 15 rounds. Over the remaining 15 rounds, the other mechanism was used to determine the prize winner in each group of size n. The change in the mechanism was *not* announced in advance. For each session, we used a fixed parameter set for $\{n, \beta\}$, either $\{2, .25\}$, $\{2, .75\}$, $\{10, .25\}$, or $\{10, .75\}$ for all 30 rounds (under both mechanisms). To minimize the consequences of possible order effects, we reversed the order of mechanisms used in the first and last 15 rounds across sessions involving the same $\{n, \beta\}$ treatment conditions.

A summary of the session characteristics is provided in Table 3.

	Lottery First 15 Rounds Auction Last 15 Rounds	Auction First 15 Rounds Lottery Last 15 Rounds	Total Sessions
$n = 2$, $\beta = .25$	2 Sessions	2 Sessions	4
$n = 2$, $\beta = .75$	2 Sessions	2 Sessions	4
$n = 10$, $\beta = .25$	2 Sessions	2 Sessions	4
$n = 10$, $\beta = .75$	2 Sessions	2 Sessions	4

Table 3: Experimental Design

In the $n = 2$ treatment, the 20 subjects were randomly paired at the start of each of the 30 rounds to form 10 groups of size 2. In the $n = 10$ treatment, the 20 subjects were randomly matched into two groups of size 10 at the start of each of the 30 rounds so that there were 2 groups of size 10. We used random matching each period so as to avoid repeated game effects.

Subjects were University of Pittsburgh undergraduates with no prior experience with the experimental setting. No subject participated in more than one experimental session. Subject interactions and decision-making were anonymous and were conducted using networked PCs in the Pittsburgh Experimental Economics Laboratory. Prior to the first round of play, subjects were given written instructions that were also read aloud in an effort to induce common knowledge of endowments, the prize, the mechanism for winning the prize and the value of tokens in terms of dollars. Continuation instructions were provided and read aloud following the first 15 rounds of play; these continuation instructions explained the change in the mechanism for determining the prize winner that would be in effect for the final 15 rounds of play. Copies of the instructions used in $\{n = 10, \beta = .25\}$ all-pay auction followed by lottery treatment are provided in an Appendix; other instructions are similar.

The sequence of play of each round of a session was as follows. Each subject was endowed with 400 tokens. They were instructed that they could bid any number of these tokens for a prize of 100 tokens. The winner in their group of size n (2or 10) was determined according to the mechanism which was used for that round. Specifically, subjects were instructed that, in the all-pay auction, the winner was the player who bids the most tokens and that, in the event of a tie, the winning bidder would be randomly chosen from among all those who bid the most tokens. When the lottery was the mechanism, subjects were instructed that the winner was chosen randomly from all players who bid at least 1 token; each bidder's chance of winning was set equal to the ratio of their bid to the total tokens bid in that round. Importantly, subjects were instructed that, if the total amount bid for the prize by all n members of their group did not equal or exceed the prize value, 100 tokens, then the prize would not be offered. In that case, all bids were returned and subjects ended the period with their endowment of 400 tokens. If the total amount bid for the prize by all n group members equaled 100 or more, then the prize was awarded. Finally subjects were instructed that amounts bid in excess of the $V = 100$ token prize would be placed in a "group account". Subjects were informed that all members of their group of size n, even those who did not bid any tokens toward the 100 token prize/group account would earn additional tokens based on the total number of tokens in the group account. The amount of additional tokens that each member of the group received from the group account was determined by the amount of tokens remaining in the group account (after the prize was paid), $\left(\sum_{j=1}^{n} b_j - 100\right)$, and the mpcr, β, and was given by $\beta\left(\sum_{j=1}^{n} b_j - 100\right)$ if $\sum_{j=1}^{n} b_j \geq 100$ and 0 otherwise. Subjects were also given a table showing how many additional tokens each group member could earn if their group account reached various token levels of 100 or more. Subjects were instructed that their earnings in each round were the sum of three numbers: 1) the amount of tokens remaining in their "private account," i.e., their endowment of 400 tokens for the round less any tokens they bid in that round (provided that $\sum_{j=1}^{n} b_j \geq 100$); 2) their prize winnings of 100 tokens if (and only if) they were the prize winner in their group for that round and 3) their payoff in tokens from the group account for that round.

At the end of each session, two rounds were randomly chosen, one from the first 15 rounds of the session and one from the last 15 rounds of the session, as these sets of rounds involved two different mechanisms. Subjects' total token amounts from the 2 randomly chosen rounds were converted into dollars at the rate of 1 token = \$0.01 (1 cent). In addition, subjects were guaranteed \$5.00 for showing up on time. Subject total earnings for this 90 minute experiment depended on the treatment. For each of the $\{n, \beta\}$ pairs we can report average total earnings per subject (across all sessions of that treatment pair) as follows: $\{2, .25\}$: \$12.82; $\{2, .75\}$: \$14.47; $\{10, .25\}$: \$15.45; and $\{10, .75\}$: \$39.20.

5 Experimental Findings

We first consider whether and how behavior varies across the treatments of our 2×2×2 experimental design. Table 4 provides a simple overview comparing the average amounts bid (Avg. Bid) and the predicted Nash equilibrium bid amounts (NE Bid) for each treatment. Table 4 also reports the average amount of public good provision, Avg. G less the prize (if awarded) and the predicted Nash equilibrium amount of public good provision, NE G. The calculations in Table 4 report averages from pooled data from all four sessions of each treatment, $\{M, n, \beta\}$ over the $T = 15$ periods of each mechanism. Tables 5–8 provide a more disaggregated view, reporting on the four *session-level* observations for Avg. Bid and Avg. G less prize for each treatment, $\{M, n, \beta\}$, over various intervals of time, T, specifically over all periods, $1 - 15$ (as in Table 4) but also for period 1 only, for periods $1 - 5$, $6 - 10$, $11 - 15$ and for the final period 15 only.

				Lottery			
β	n	Avg. Bid	NE Bid	Avg. G	NE G	Prov %	NE Prov %
.25	2	59.3	33.3	36.4	0.0	0.63	0.00
.75	2	148.6	100.0	207.9	100.0	0.80	1.00
.25	10	86.6	12.0	767.6	20.0	0.98	1.00
.75	10	201.8	36.0	1917.8	260.0	1.00	1.00
				All-Pay Auction			
β	n	Avg. Bid	NE Bid	Avg. G	NE G	Prov %	NE Prov %
.25	2	67.9	0.0	56.2	0.0	0.69	0.00
.75	2	159.3	0.0	230.3	0.0	0.82	0.00
.25	10	87.0	0.0	772.5	0.0	0.98	0.00
.75	10	210.8	0.0	2008.2	0.0	1.00	0.00

Table 4: Average Bids and Public Good Provision Across Treatments Relative to Theoretical Predictions, Averages From All Periods of All Sessions of Each Treatment

For each treatment $\{M, n, \beta\}$, the session-level average bid (Avg. Bid) is computed using data from all 20 subjects of the session over all T periods of each mechanism. This number can be compared with the theoretical predictions in the column of Table 4 labeled 'NE bid'.[5] The session-level average contribution to the public good, Avg. G, excludes the prize amount of $V = 100$, if the prize was awarded and is equal to 0 if the prize was not awarded or if the sum of a group's bids was exactly equal to 100 That measure is calculated over interval T as:

$$\frac{1}{T}\sum_{t=1}^{T}\frac{n}{20}\sum_{k=1}^{20/n}\max\left\{\sum_{j=1}^{n}b_{j,t}^{k}-100,0\right\}.$$

This number can be compared with the theoretical predictions in the column of Table 4 labeled 'Avg. G'. Finally, the last column of Table 4 reports the average frequency with which the public good was provided (Prov %), i.e., the frequency with which group totals equaled or exceeded 100 tokens along with the NE prediction (NE Prov %). Based on the numbers reported in these tables we have:

[5] The average bid actually paid may be less than this number depending on whether contributions exceeded the prize level $V = 100$ or not. However, the theoretical predictions are for the 'ex-ante' bid amount reported in Tables 4, 5 and 6. By contrast, the Avg. G measure, described below takes account of whether each group of n players met the prize threshold or not.

	Average Amount Bid in Round Number(s):					
Session No, $\{\beta, n\}$	1-15	1	1-5	6-10	11-15	15
1 $\{.25, 2\}$	68.7	93.7	83.3	72.2	50.4	45.7
2 $\{.25, 2\}$	53.9	63.4	59.8	49.9	52.1	48.8
3 $\{.25, 2\}$	66.3	77.7	76.5	69.6	52.9	51.4
4 $\{.25, 2\}$	48.3	51.0	54.6	46.4	43.8	46.2
Average Sess. 1-4	59.3	71.4	68.6	59.5	49.8	48.0
1 $\{.75, 2\}$	165.0	126.0	183.8	180.0	131.3	98.5
2 $\{.75, 2\}$	135.6	143.7	133.9	129.1	124.0	248.0
3 $\{.75, 2\}$	212.4	212.4	250.6	236.2	177.6	154.3
4 $\{.75, 2\}$	81.3	91.7	95.4	80.4	68.0	81.2
Average Sess. 1-4	148.6	143.4	165.9	156.4	125.2	145.5
1 $\{.25, 10\}$	119.6	124.8	154.3	124.0	80.6	96.2
2 $\{.25, 10\}$	50.2	78.9	70.9	46.4	33.1	17.4
3 $\{.25, 10\}$	135.3	140.5	167.1	133.3	105.6	96.5
4 $\{.25, 10\}$	41.3	114.9	69.3	29.5	25.1	45.8
Average Sess. 1-4	86.6	114.8	115.4	83.3	61.1	64.0
1 $\{.75, 10\}$	252.5	287.1	258.6	268.2	230.7	222.1
2 $\{.75, 10\}$	235.2	170.6	233.5	251.4	220.6	240.5
3 $\{.75, 10\}$	165.8	199.0	197.4	177.8	122.3	137.0
4 $\{.75, 10\}$	153.6	102.7	146.5	158.4	156.0	171.6
Average Sess. 1-4	201.8	189.8	209.0	213.9	182.4	192.8

Table 5: Session-Level Average Bids Under the Lottery Mechanism Over Various Intervals of Time

Finding 1 *For most treatments, average bids and public good provision are much larger than theoretical predictions.*

Support for this finding can be found in Table 4 which reveals that both Avg. Bid and Avg. G are, in all cases, substantially greater than Nash equilibrium predicted values (NE Bid and NE G, respectively) under both self-financed prize-based mechanisms. Further support for this finding at the session-level, is provided in Tables 5–8. Consider first the lottery mechanism. Using the four session-level observations for each $\{n, \beta\}$ treatment on Avg. Bid over rounds 1-15 as reported in the second column of Table 5 a non-parametric Wilcoxon signed rank test allows us to reject the null hypothesis that Avg. Bid=NE Bid (the latter are given in Table 4) in favor of the alternative that Avg. Bid is greater than the NE prediction ($p < .10$) in three of the four treatment conditions (4 tests); the sole exception is for the $n = 2, \beta = .75$ treatment where the NE Bid prediction is 100. Not surprisingly, a similar finding holds if we use the four session level observations on Avg G. over rounds 1-15 as reported in the second column of Table 7 and test the null hypothesis that Avg G=

	Average Amount Bid in Round Number(s):					
Session No, $\{\beta, n\}$	1-15	1	1-5	6-10	11-15	15
1 $\{.25, 2\}$	51.1	62.9	56.7	55.7	40.8	29.0
2 $\{.25, 2\}$	82.2	112.4	112.1	82.7	52.0	43.5
3 $\{.25, 2\}$	58.3	76.5	67.7	60.0	47.1	42.0
4 $\{.25, 2\}$	80.2	112.0	102.3	79.1	59.2	79.5
Average Sess. 1-4	67.9	90.9	84.7	69.4	49.8	41.8
1 $\{.75, 2\}$	171.7	172.2	170.2	184.5	160.3	129.5
2 $\{.75, 2\}$	221.4	212.4	250.6	236.2	177.6	154.3
3 $\{.75, 2\}$	135.7	209.3	145.2	144.5	117.3	96.4
4 $\{.75, 2\}$	108.5	133.9	119.6	103.1	102.9	104.4
Average Sess. 1-4	159.3	181.9	171.4	167.1	139.5	121.1
1 $\{.25, 10\}$	72.3	160.7	107.8	73.1	36.0	31.5
2 $\{.25, 10\}$	99.8	107.8	124.8	107.5	67.2	87.1
3 $\{.25, 10\}$	88.7	117.7	106.9	92.5	66.8	52.9
4 $\{.25, 10\}$	87.3	114.9	140.2	82.4	39.3	30.0
Average Sess. 1-4	87.0	125.3	119.9	88.9	52.3	50.3
1 $\{.75, 10\}$	254.7	274.0	265.8	260.1	238.0	263.6
2 $\{.75, 10\}$	229.5	223.1	228.8	240.5	219.1	221.9
3 $\{.75, 10\}$	209.7	131.9	210.4	227.6	191.2	216.0
4 $\{.75, 10\}$	149.4	170.3	161.5	149.0	137.8	125.3
Average Sess. 1-4	210.8	199.8	216.6	219.3	196.5	206.7

Table 6: Session-Level Average Bids Under the All-Pay Auction Mechanism Over Various Intervals of Time

NE G.[6] These same conclusions would remain unchanged if we used as our session level observations the values of Avg. Bid or Avg. G over just the final 5 rounds (rounds 11-15) of the lottery mechanism (as reported in the sixth column of Tables 5 and 7. We conclude that in three of our four treatments of the provisional prize lottery mechanism there is significant over-provision of the public good relative to theoretical predictions.

Consider next the provisional prize all-pay auction mechanism. We cannot similarly test the NE prediction that Avg. Bid = Avg $G = 0$ under this mechanism as the prediction always lies at the boundary of feasible bids and public good provision levels. Nevertheless, it seems clear from Tables 6-8 that the experimental evidence runs counter to that prediction as both Avg. Bid and Avg G are, for all $\{n, \beta\}$ treatments and all sessions of the all-pay auction mechanism substantially greater than zero.

We note further, as revealed in Table 4, that the frequency with which the public good is actually provided (i.e. the frequency with which contributions exceed the prize

[6] For the $n = 2$, $\beta = .25$ treatment of the lottery mechanism, NE $G = 0$ and we cannot test this prediction as it lies at the boundary of feasible public good provision.

	Average G Less Prize in Round Number(s):					
Session No, $\{\beta, n\}$	1-15	1	1-5	6-10	11-15	15
1 $\{.25, 2\}$	49.4	95.2	72.2	51.8	24.2	10.2
2 $\{.25, 2\}$	31.7	55.5	41.9	27.3	26.0	22.6
3 $\{.25, 2\}$	42.4	63.2	57.0	47.5	22.8	16.2
4 $\{.25, 2\}$	22.0	24.8	28.5	23.0	14.7	22.9
Average Sess. 1-4	36.4	59.7	49.9	37.4	21.9	18.0
1 $\{.75, 2\}$	233.1	151.9	267.5	262.2	169.6	102.4
2 $\{.75, 2\}$	182.9	215.4	199.6	178.3	170.9	171.3
3 $\{.75, 2\}$	326.7	341.9	398.5	306.0	275.7	353.9
4 $\{.75, 2\}$	89.01	116.20	113.28	80.82	72.92	105.10
Average Sess. 1-4	207.9	205.6	236.6	204.9	180.3	179.2
1 $\{.25, 10\}$	1096.3	1147.5	1443.4	1139.5	706.0	862.0
2 $\{.25, 10\}$	401.6	689.0	609.4	364.3	231.0	74.0
3 $\{.25, 10\}$	1253.3	1305.0	1569.0	1232.6	956.0	865.0
4 $\{.25, 10\}$	319.2	1048.5	592.9	204.6	160.2	357.8
Average Sess. 1-4	767.6	1047.5	1053.7	735.3	513.3	539.7
1 $\{.75, 10\}$	2425.0	2770.5	2486.1	2582.2	2073.4	2121.0
2 $\{.75, 10\}$	2251.8	1606.0	2235.1	2414.3	2106.1	2305.0
3 $\{.75, 10\}$	1558.2	1889.5	1874.0	1677.5	1123.1	1270.0
4 $\{.75, 10\}$	1436.0	926.7	1364.7	1483.8	1420.5	1615.5
Average Sess. 1-4	1917.8	1798.2	1990.0	2039.5	1680.8	1827.9

Table 7: Session-Level Average Group Contribution Less Prize Under the Lottery Mechanism Over Various Intervals of Time

level) averages 63 percent or higher in all treatments and is generally increasing in n or β; in the case where $n = 10$, the overall average public good provision frequency is very close to the NE prediction of 100 percent.

Our next finding is one where there is some consistency with the comparative statics implications of the theory, at least in the case of the lottery mechanism. Specifically, if we hold the group size, n, fixed then a larger β should result in higher individual bids and greater public good provision under the lottery mechanism, and indeed this is the case. By contrast, under the all-pay auction mechanism, a larger β should not result in higher individual bids or greater public good provision. Note that the latter comparative static prediction for the all-pay auction would also hold true if the prize were exogenously fixed (see Table). However, inconsistent with this theoretical prediction, we find that an increase in β leads to higher individual bids and greater public good provision just as in the case of the lottery mechanism. We summarize this as follows:

Finding 2 *For a fixed group size n, larger β leads to higher individual bids and to higher public good provision under both mechanisms.*

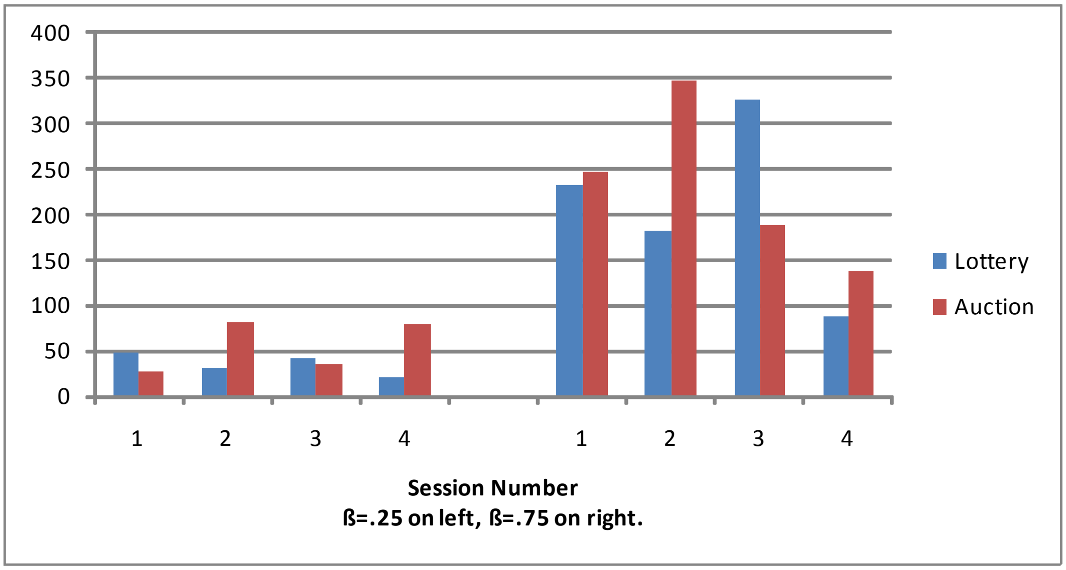

Figure 2: Public good provision under the lottery and all-pay auction mechanisms when $n = 2$: $\beta = .25$ versus $\beta = .75$.

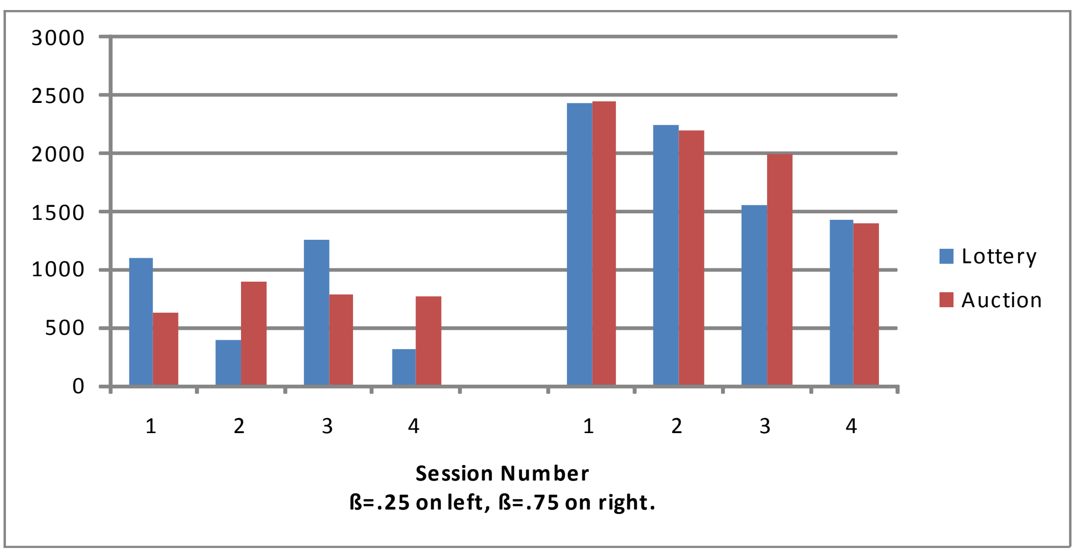

Figure 3: Public good provision under the lottery and all-pay auction mechanisms when $n = 10$: $\beta = .25$ versus $\beta = .75$

	Average G Less Prize in Round Number(s):					
Session No, $\{\beta, n\}$	1-15	1	1-5	6-10	11-15	15
1 $\{.25, 2\}$	27.5	45.7	33.0	36.1	13.5	1.2
2 $\{.25, 2\}$	82.6	124.8	131.1	80.2	36.6	26.0
3 $\{.25, 2\}$	35.1	57.0	48.0	35.4	21.8	20.1
4 $\{.25, 2\}$	79.5	144.0	114.1	74.0	50.5	88.1
Average Sess. 1-4	56.2	92.9	81.6	56.4	30.6	33.9
1 $\{.75, 2\}$	246.6	249.2	247.3	270.6	222.0	163.9
2 $\{.75, 2\}$	348.4	324.8	403.2	378.3	262.9	221.1
3 $\{.75, 2\}$	187.6	335.1	208.0	203.3	151.5	112.2
4 $\{.75, 2\}$	138.6	183.1	157.4	131.8	126.6	128.7
Average Sess. 1-4	230.3	273.1	254.0	246.0	190.8	156.5
1 $\{.25, 10\}$	626.0	1507.0	977.7	631.0	269.5	264.5
2 $\{.25, 10\}$	900.4	977.6	1148.2	975.3	577.7	800.5
3 $\{.25, 10\}$	787.3	1077.0	969.0	824.7	568.4	429.0
4 $\{.25, 10\}$	776.1	1049.0	1302.0	723.5	302.7	199.5
Average Sess. 1-4	772.5	1152.7	1099.2	788.6	429.6	423.4
1 $\{.75, 10\}$	2446.5	2639.5	2558.4	2501.1	2280.1	2536.0
2 $\{.75, 10\}$	2194.8	2130.5	2188.4	2304.7	2091.4	2118.5
3 $\{.75, 10\}$	1997.4	1218.5	2003.5	2176.2	1812.4	2060.0
4 $\{.75, 10\}$	1394.0	1603.0	1514.5	1389.7	1277.7	1152.5
Average Sess. 1-4	2008.2	1897.9	2066.2	2092.9	1865.4	1966.8

Table 8: Session-Level Average Group Contribution Less Prize Under the All-Pay Auction Mechanism Over Various Intervals of Time

Support for Finding 2 is found in Tables 4-8 and in Figures 2 and 3 which illustrate session-level observations on Avg G over all 15 rounds of each treatment. When $n = 2$, a switch from $\beta = .25$ to $\beta = .75$ causes G to increase, on average, by a factor of 5.7 in the lottery treatment and by a factor of 4.1 in the all-pay auction treatment. Similarly, when $n = 10$, a switch from $\beta = .25$ to $\beta = .75$ leads, on leads G to increase, on average, by a factor of 2.5 in the lottery treatment and by a factor of 2.6 in the auction treatment. For each mechanism, if we fix n at 2 or 10, the amount of G is always significantly higher when $\beta = .75$ as compared with when $\beta = .25$ according to non-parametric, Mann-Whitney tests of the null hypothesis of no difference using the session level observations that are illustrated in Figures 2 and 3 ($p = .02$ – lowest possible p-value– for all four tests $n = 2$ and $n = 10$; lottery, auction).

Our next finding considers the impact of group size, holding β fixed. According to the theory, see Table 1, for fixed β, a larger group size n should lead to:

- lower individual bids but higher public good provision under the lottery mechanism,
- zero individual bids and zero public good provision under the all-pay auction

mechanism.

Finding 3 *For fixed β, larger n does not reduce individual amounts bid but it does result in higher public good provision under both mechanisms.*

Support for Finding 3 is again found in Tables 4-8 and in Figures 2-3. Consider first the session-level observations for Avg. Bid over rounds 1-15 as reported in the second columns of Tables 5 and 6. Suppose we hold β fixed at either .25 or .75 and we consider whether average bids are different when $n = 2$ as compared with when $n = 10$. For three of the four treatment conditions, lottery with $\beta = .25$, lottery with $\beta = .75$ and all-pay auction with $\beta = .75$, non-parametric Mann-Whitney tests indicate that we cannot reject the null hypothesis of no difference in average bids across the two different values for n ($p > .10$ for all three tests). For the all-pay auction with $\beta = .25$, we can reject the null hypothesis of no difference in favor of the alternative that bids are significantly higher when $n = 10$ than when $n = 2$ ($p = .08$).

While average bids should decline as n increases holding β fixed, under the lottery mechanism, the NE prediction calls for G to nevertheless *increase* in this same scenario. This aspect of the lottery theory does find support in the experimental data. Intuitively, as we found no decrease in the individual amounts bid as n increases from 2 to 10, it should come as no surprise that G is higher under both mechanisms as n is increased from 2 to 10.

Confirmation again comes from non-parametric Mann-Whitney tests on the session-level observations illustrated in Figures 2-3 (see also column 2 of Tables 7 and 8). Fixing $\beta = .25$ or .75, an increase in n from 2 to 10 leads to a significantly higher public good provision G under both mechanisms (the null hypothesis of no difference in G is rejected, $p = .02$ – lowest possible p-value– for all four tests, $\beta = .25$, $\beta = .75$; lottery, auction).

We note further that non-provision of the public good is predicted under the lottery mechanism when $n = 2$ and $\beta = .25$, however as Table 4, indicates, provision actually occurred, on average 63% of the time in this treatment. Indeed, holding β fixed, provision of the public good increased as n was increased under both mechanisms. Recall from Finding 3 that individual bid amounts did not generally change, for fixed β as n was increased. Nevertheless, having more individual bidders (larger n) biding similar amounts ensured that the provision point where contributions exceeded the prize level of $V = 100$, was more likely to be achieved as n was increased.

We now turn to our main finding, concerning the efficiency of the two mechanisms. According to the theory, for fixed β and n, the lottery design should result in higher public good provision. By contrast we find that:

Finding 4 *For fixed β and n, public good provision is insignificantly different across the two provisional, prize-based mechanisms.*

Support for finding 6 is shown in Figure 4. Statistical support for finding 6 is found by conducting four Mann-Whitney tests using the four session-level observations for G for each treatment (auction or lottery) for the same values of $\{\beta, n\}$. Using session-level averages for G over all 15 rounds as reported in the second column of Tables

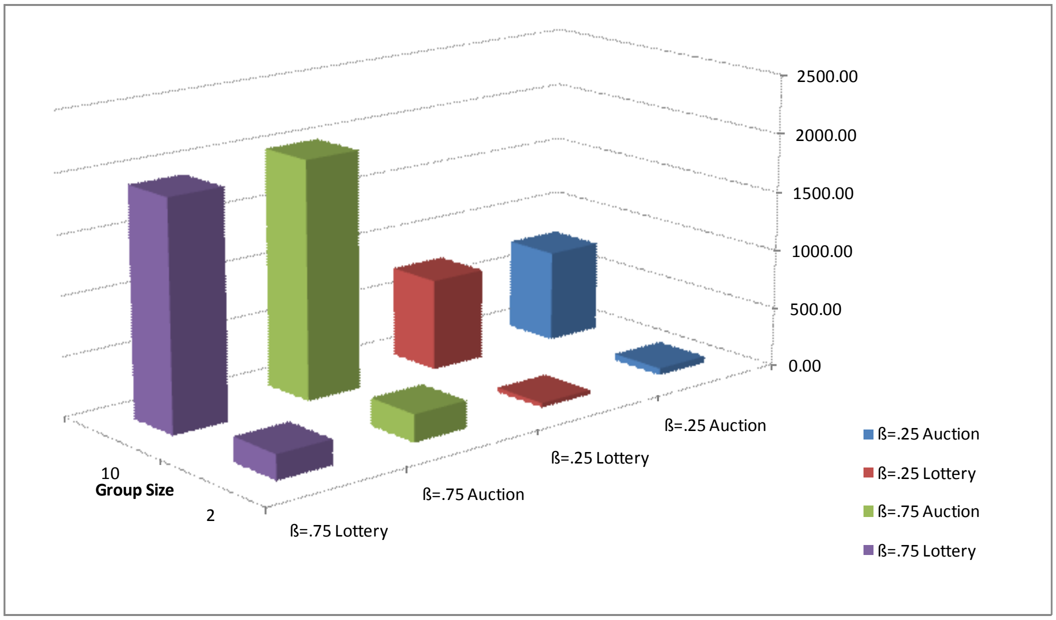

Figure 4: Average Group Contribution Less 100 Token Prize, All Data from All Sessions of All Treatments

7 and 8 a Mann-Whitney test indicates that we cannot reject the null hypotheses of no difference in public good provision in any pairwise test between the lottery and all-pay auction mechanisms for the same $\{\beta, n\}$ values. ($p > 0.10$ for all four tests).

A typical pattern of behavior in public good games is a decline in contributions over time as individuals learn to give less. We also find evidence of such learning behavior in our experimental data. Tables 5-6 report average bids over all rounds 1-15, in round 1 alone, over rounds 1-5, 6-10, 11-15 and in round 15 alone. Tables 7-8 do the same for public good provision levels (Avg. G). Finally, Figure 5 illustrates the average value of G over rounds 1-15 as a percentage of total endowment using all data from all sessions of each treatment $\{M, n, \beta\}$.

The Tables and Figure 5 provide evidence that average bids and public good provision are declining with experience in nearly all sessions of all treatments. Since overall average bids (over all rounds 1-15) as reported in Table 4 were found to have generally exceeded Nash equilibrium predictions, the decay in bids and public good provision over time serves to bring behavior closer to equilibrium predictions by the final rounds of each treatment. We summarize this finding as follows.

Finding 5 *We observe a decline in both the average individual amount bid and in public good provision in the last 5 rounds as compared with the first five rounds under both mechanisms.*

Consider first the session-level average individual bids in rounds 1-5 versus rounds 11-15 under the various treatments of the lottery or auction mechanisms, as reported

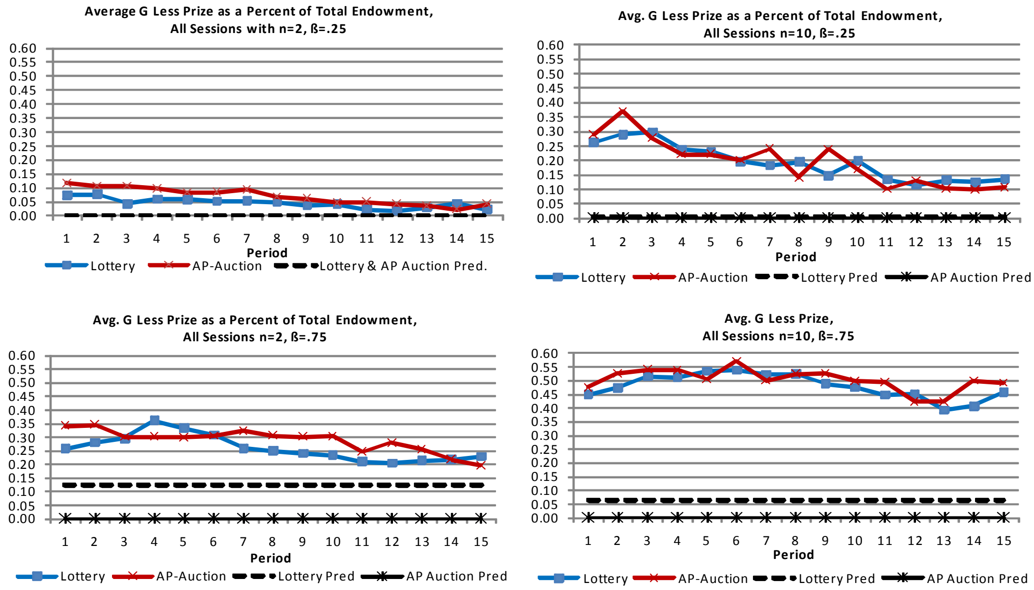

Figure 5: Average Public Good Provision G Less Prize as a Percent of Total Endowment Over Rounds 1-15. Averages are from all 4 Sessions of Each Treatment (M,$n\beta$).

in columns 4 and 6 of Tables 5 and 6. Using a Wilcoxon signed-rank test for matched pairs on the session-level observations for each treatment we can reject the null hypothesis of no difference in average bids over rounds 1-5 as compared with average bids over rounds 11-15 in the same session in favor of the alternative that average bids are *lower* in the final 5 rounds as compared with the first five rounds of seven of our eight treatments ($p < .10$ in seven tests: 1) lottery, $n = 2$, $\beta = .25$; 2) lottery $n = 2$, $\beta = .75$; 3) lottery $n = 10$, $\beta = .25$; 4) auction $n = 2$, $\beta = .25$; 5) auction $n = 2$, $\beta = .75$; 6) auction $n = 10$, $\beta = .25$; 7) auction $n = 10$, $\beta = .75$. The sole exception is the lottery $n = 10$, $\beta = .75$ treatment where we cannot reject the null hypothesis of no difference $p = .14$. However, the exception arises because in just one session of that treatment, number 4, average bids in the last 5 rounds were higher than in the first 5 rounds; in the other three sessions of that treatment they were all lower.

Consider next the session-level average amounts of public good provision in rounds 1-5 versus rounds 11-15 under the various treatments of the lottery or auction mechanisms, columns 4 and 6 of Tables 7 and 8. Here the results mirror those found for average individual bids. There is a statistically significant decrease in public good provision G less the 100 token prize from the first 5 to the last 5 rounds of all sessions of all treatments ($p < .10$) except the lottery $n = 10$, $\beta = .75$ treatment where we cannot reject the null hypothesis of no difference $p = .14$.

While the decline over time in average individual bids and public good provision brings behavior more in line with NE predictions, there remains, in the last 5 rounds, substantial over-bidding and over-provision of the public good relative to equilibrium predictions. Indeed, Finding 1 remains unchanged if we restrict attention to average individual bids and public good provision G less the prize in rounds 11-15 instead of over all rounds 1-15. Only in the case of the lottery mechanism where $n = 2$ and $\beta = .25$ –where the NE bid and public good provision less the prize are both 100– can we not reject the null hypothesis of no difference between average behavior and the NE predictions using the Wilcoxon signed-ranks test ($p > .10$). Recall that for the all-pay auction mechanism, we cannot perform a statistical test as the NE bid and public good provision are at the zero lower bound. However it is apparent from Tables 6 and 8 and Figure 5 that bids and public good provision remain substantially greater than 0 even in the final 5 rounds of all all-pay auction sessions.

The pattern we have observed of excessive contributions to the public good and the decline in such contributions over time as participants gain experience (see Figure 5), is a very typical pattern found in the literature on VCM games (see, e.g. Isaac et al. (1984)) and in the literature on prize-based fundraising mechanisms (see, e.g., Corazzini et al. (2010)). Excess contributions may be explained by a variety of factors including confusion, altruism, conditional cooperation or concerns for social efficiency. Here our aim is not to identify which of these various mechanisms may be at work but to note that despite very stark differences in predicted behavior between the lottery and the all-pay auction mechanisms, there does not seem to be much difference in bidding behavior, public good provision or in the general pattern of decay in these variables over time. That subjects are converging toward NE bids and public good provision levels as they gain experience is encouraging. We speculate that this equilibration process may take a longer period of time than is possible in the laboratory; over the short horizon of time that we are able to gather data, there appears to be no difference in subjects' behavior under these two provisional prize-based fundraising mechanisms.

6 Conclusions

We have studied two mechanisms for raising charitable contributions, a lottery and an all-pay auction. The main innovation of our theoretical model is our assumption that these prize-based mechanisms must be self–financing. Specifically, we require that contributions must equal or exceed the prize level V for the prize to be awarded. Public good provision G is thus the net value $G - V$ if positive, and 0 otherwise. We study a setting with a known, fixed prize of common value V, with common endowments and complete information. In this environment we find that bidding behavior under both the lottery and the all-pay auction mechanisms is characterized by pure strategies and that under certain conditions on endowments, the lottery mechanism provides greater public good provision than does the all-pay auction mechanism. These theoretical results are new to the literature.

We have also conducted an experimental test of these theoretical predictions. The main innovation of our experiment is that we have varied both n and the mpcr (β)

on the public good and we have considered some of the comparative statics implications of the Nash equilibrium predictions. Relative to theoretical predictions we find substantial over-bidding and over-provision of the public good under both provisional prize-based mechanisms. However, there is also evidence that individuals learn over time to bid less under all treatment conditions so that over-bidding and over-provision decline with experience. Still, final amounts bid and levels of public good provision remain substantially higher than theoretical predictions in most treatments.

We find that bids are always large and positive under the all-pay auction mechanisms which is inconsistent with theoretical predictions. Under the lottery mechanism we find more consistency with the theory: for fixed n, bids and public good provision increase as β increases and for fixed β public good provision increases as n increases. However we also observe that for fixed fixed β, bids do not decrease as n increases a finding that is inconsistent with the lottery theory. Perhaps most importantly, despite the prediction that the lottery will yield greater public good provision given our choices for e, V and for all $\{n, \beta\}$ pairs, we find no difference in public good provision between the lottery and the all-pay auction mechanisms.

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Appendix A

Proof of Proposition 1.

Consider player i's decision when her opponents spend $\sum_{j\neq i} x_j = X_{-i}$. The first order condition, if the public good is produced, is

$$\beta - 1 + \frac{X_{-i}}{(x_i + X_{-i})^2} V = 0.$$

In the symmetric equilibrium,

$$x_1 = ... = x_n = x^*,$$

or

$$x^* = \min\left\{\frac{(n-1)}{n^2}\frac{V}{(1-\beta)}, e\right\}. \tag{17}$$

Since the public good is produced, the total spending must be at least equal to the prize value,

$$nx^* = n\min\left\{\frac{(n-1)}{n^2}\frac{V}{(1-\beta)}, e\right\} = \min\left\{\frac{(n-1)}{n}\frac{V}{(1-\beta)}, ne\right\} \geq V,$$

or

$$\beta n \geq 1. \tag{18}$$

Note that (18) is the efficiency condition. Since the prize is self-financed, the public good provision is

$$\widetilde{G} = nx^* - V = \min\left\{\frac{(\beta n - 1)}{n(1-\beta)} V, ne - V\right\}.$$

If the public good is not produced, then either the efficiency condition (18) does not hold or the endowment is too small, $e < \frac{V}{n}$. In these cases there are many symmetric equilibria $(x^{**}, ..., x^{**})$,

$$x_1 = ... = x_n = x^{**},$$

where

$$nx^{**} < V. \tag{19}$$

In these symmetric equilibria each player obtains the same payoff, e. Since there are no profitable deviations in equilibrium, the following condition must hold if $e > \frac{V}{n}$:

$$H(x_i) \equiv (e - x_i) + \beta(x_i + (n-1)x^{**} - V) + \left(\frac{x_i}{x_i + (n-1)x^{**}}\right) V \leq e, \tag{20}$$

for any x_i such that $(x_i + (n-1)x^{**}) \geq V$, or $x_i \geq V - (n-1)x^{**}$. Note that

$$H'(x_i) = -1 + \beta + \frac{(n-1)x^{**}}{(x_i + (n-1)x^{**})^2} V.$$

Then,

$$H'(x_i) \leq 0$$

if

$$x_i \geq \sqrt{(n-1)\,x^{**}\frac{V}{(1-\beta)}} - (n-1)\,x^{**}.$$

Since inequality (19) holds and inequality (18) does not hold, we get

$$\frac{(n-1)}{(1-\beta)}x^{**} < \frac{(n-1)}{(1-\beta)\,n}V < V,$$

because

$$\frac{(n-1)}{(1-\beta)\,n} < 1.$$

Therefore, the following inequality holds

$$\sqrt{\left[\frac{(n-1)\,x^{**}}{(1-\beta)}\right]V} - (n-1)\,x^{**} < V - (n-1)\,x^{**},$$

which means that

$$\max_{x_i \geq V-(n-1)x^{**}} H(x_i) = H(V-(n-1)\,x^{**}) = e.$$

■

Proof of Proposition 2.

Suppose that there exists a symmetric equilibrium where the public good is provided. If such an equilibrium is in pure strategies, then each player submits an equilibrium bid $b^* \in (0, e]$ and each player has an equal chance to win the prize, V. If $b^* < e$, then a player can increase his bid by $\varepsilon > 0$ and win the prize for sure which means that $b^* < e$ cannot be in an equilibrium. If $b^* = e$, then each player obtains payoff $\frac{V}{n} + \beta(ne - V)$. Consider the most profitable deviation - a zero bid. If a player submits a zero bid, his payoff becomes

$$\begin{cases} e + \beta((n-1)\,e - V), & \text{if } (n-1)\,e \geq V, \\ e, & \text{if } (n-1)\,e < V. \end{cases}$$

In equilibrium, the deviation does not increase the player's payoff, or

$$\begin{cases} \frac{V}{n} + \beta(ne - V) \geq e + \beta((n-1)\,e - V), & \text{if } (n-1)\,e \geq V, \\ \frac{V}{n} + \beta(ne - V) \geq e, & \text{if } (n-1)\,e < V. \end{cases} \tag{21}$$

Therefore,

$$\begin{cases} \frac{V}{(1-\beta)n} \geq e, & \text{if } e \geq \frac{V}{(n-1)}, \\ (\beta n - 1)\,e \geq \left(\frac{\beta n-1}{n}\right)V, & \text{if } e < \frac{V}{(n-1)}. \end{cases} \tag{22}$$

Consider the inequalities in (22). Note that in the first case,

$$\frac{V}{(n-1)} \leq e \leq \frac{V}{(1-\beta)\, n},$$

which implies that

$$(1-\beta)\, n \leq (n-1)\,,$$

or

$$1 \leq \beta n, \tag{23}$$

which means that it is efficient to provide public good.

The second case can take place also only if condition (23) holds. Hence, there exists a symmetric pure strategy equilibrium where each player bids his entire endowment, $b^* = e$, if the inequalities in (22) hold:

$$\frac{V}{n} \leq e \leq \frac{V}{(1-\beta)\, n}. \tag{24}$$

Now suppose that there exists a symmetric mixed-strategy equilibrium where the public good is provided. First, note that there cannot be any mass points for the same reason that there cannot be a pure-strategy equilibrium: each player has an incentive to increase his bid by $\varepsilon > 0$ at the mass point. Second, note that the winning bid must be at least $\frac{V}{n}$ because we assume that the public good will be provided. It follows that no player bids in the interval $\left(0, \frac{V}{n}\right)$ in the equilibrium. Third, note that there cannot be a lower bound $\underline{b} > 0$ in the support of the equilibrium distribution because such a bid will have zero probability of winning - there are no mass points from our first observation - and therefore any player would prefer to bid zero instead of $\underline{b} > 0$. It means that there is no mixed strategy symmetric equilibria where public good is provided.

The all-pay auction game can have symmetric pure-strategy equilibria where public good is not provided. Indeed, there exists a unique such an equilibrium where each player bids zero. The statement of the proposition follows from the following observation. Suppose that $(t, ..., t)$ is a symmetric pure strategy equilibrium where public good is not produced. It means that

$$nt < V$$

and each player obtains payoff e in the equilibrium. Suppose that player i deviates and submits bid $V - (n-1)\, t$ just to ensure that the prize is rewarded. Then, player i will be the prize winner, since his bid is the highest, and he obtains payoff $V + (e - (V - (n-1)\, t))$. In the equilibrium, it must be the case that

$$e \geq V + (e - (V - (n-1)\, t))\,,$$

or

$$0 \geq (n-1)\, t,$$

which means that $t = 0$. ■

Appendix B: Sample Instructions Used in the Lottery-Auction n=2, β=.75 treatment

Instructions Part One

Overview

Welcome to this experiment in the economics of decision-making. Please read these instructions carefully as they explain how you earn money from the decisions you make in today's session. There is no talking for the duration of this experiment. If you have a question, please raise your hand.

Today's experiment is divided into two parts, each consisting of 15 rounds. In each round of the first half, you participate in a simple decision-making game that is described below. You will receive instruction for the second part of the experiment following the conclusion of the first part. You will make your decisions using the computer workstation, which will also provide you with feedback about the outcomes of those decisions.

There are 20 participants in today's experiment. At the beginning of each round, you will be assigned randomly to one of two groups of 10 participants, either group 1 or 2. The group to which you are randomly assigned each round is indicated on your screen. While you may be assigned to the same group number (1 or 2) more than once in succession, the composition of participants in the group to which you are assigned will vary from round to round. You will play each round only with the members of your group of size 10. You will not be told the identity of any member of your group, nor will any of them know your identity even after the session is over. Your earnings will depend on the choices you make as well as the choices made by the other participants in your group.

The Game

At the start of each round, each member of your group including yourself is endowed with 400 tokens. You are asked whether you would like to contribute any number of your endowment of tokens toward the possibility of winning a prize of 100 tokens. Your token contribution decision is made anonymously; no participant can associate you with your decision.

Specifically, on the decision screen for each round you are asked: How many of your 400 tokens would you like to contribute? In the input box, type in the number of tokens you want to contribute, any number between 0 and 400, inclusive. You can change your mind anytime prior to clicking the OK button. When you are satisfied with your choice, click the OK button.

After all participants have clicked the OK button, the computer program will calculate the total number of tokens that all members of your group of size 10 (including you) have contributed. Let us call this number X.

If $X<100$, then the 100 token prize is not awarded to any member of your group. Each group member gets back any of his/her 400 tokens contributed toward winning the prize. Earnings for the round are 400 tokens for each subject.

If $X\geq100$, then the 100 token prize is randomly awarded to one (and only one) member of your group who contributed more than zero tokens toward winning the prize. While the computer program randomly selects one member of your group contributing more than zero tokens as the prize winner, your chance of winning the 100 token prize in this random selection is equal to the number of tokens you contributed toward winning the prize, c, divided by the total number of tokens contributed by all members of your group including you, X. That is, you have a c/X chance of winning the 100 token prize. The more tokens you contribute, c, relative to the total X, the greater is your chance of winning the 100 token prize. But notice that each member of your 2-person group who contributes more than 0 tokens toward winning the prize has some chance of winning the prize. Tokens that you do not contribute toward winning the 100 token prize remain in your "private" account.

If X≥100, then the amount X-100 of tokens will be placed in a "group" account. All 10 members of your group, even those who did not contribute any tokens toward winning the 100 token prize will earn additional tokens based on the number of tokens in the group account.

Specifically, if X≥100, each member of your 10-person group will earn .75×(X-100) tokens. These tokens are in addition to the tokens that remain in your private account (400-c) or the 100 token prize awarded to the winner. The table below gives you a non-exhaustive list of your possible earnings from the group account.

If X is	then (X-100) is	and the Tokens Earned by Each Member of the Group is
100	0	0
150	50	37.5
200	100	75
250	150	112.5
300	200	150
350	250	187.5
400	300	225
450	350	262.5
500	400	300
1000	900	675
1500	1400	1050
2000	1900	1425
2500	2400	1800
3000	2900	2175
3500	3400	2550
4000	3900	2925

If X<100, no tokens are placed in the group account.

<u>Earnings</u>

Your total tokens for each round are the sum of three items.

1. The number of tokens that remain in your private account. If X<100, the number of tokens in your private account will be set equal to your endowment of 400 tokens. Otherwise, if X≥100, the number of tokens in your private account is 400-c, where c is the number of tokens that *you* contributed toward winning the 100 token prize.
2. If X≥100, AND you are the prize winner, then you receive an additional 100 token prize for that round.

3. If $X \geq 100$, you and every other member of your group earns an additional .75 ×(X-100) tokens based on the number of tokens (X-100) in the group account.

At the end of today's experimental session, the computer program will randomly select two rounds: one from the first part (15 rounds) of today's session and one from the second part. Your token total for the rounds selected will be converted into dollars at a rate of 1 token = $0.005 (1/2 cent).

Feedback

At the end of each period your computer screen will report back to you:

- The number of tokens you offered toward winning the prize, c
- The total number of tokens submitted by all members of your group including you, X.
- Whether the prize was awarded (if $X \geq 100$) or not (if $X < 100$).
- If $X \geq 100$, your percent chance of winning the prize, c/X (up to five decimal places).
- If $X \geq 100$, whether you won or lost the 100 token prize.

You will also be shown the calculation of your total token earnings for the round. Specifically, you will learn:

1. The number of tokens that remain in your private account.

If $X \geq 100$, you will also learn:

2. Prize tokens: 100 if you won the prize, 0 otherwise.
3. The number of tokens you and the other member of your group each earn from the group account, equal to .75×(X-100) tokens.

- Finally, you will be told your total tokens earned for the round, which is the sum of the token amounts in items 1-3 above.

Record Sheets

Please record the information reported to you on the outcome of each round on your record sheet under the appropriate headings. Be sure also to indicate on your record sheet your ID number.

For your convenience, the history of information reported back to you at the end of each round will appear at the bottom of your first decision screen.

Questions

Are there any questions before we begin?

Instructions Part Two

You are about to begin the second part of the experiment. This part also consists of 15 rounds.

As in the first part of today's experiment, at the start of each round in this second part, the computer program will again randomly divide you up into two groups of 10 participants, group 1 or group 2. While you may be assigned to the same group number (1 or 2) more than once in succession, the composition of participants in the group to which you are assigned will vary from round to round. You will play each round only with the members of your group of size 10. You will not be told the identity of any member of your group, nor will any of them know your identity even after the session is over. Your earnings will depend on the choices you make as well as the choices made by the other participants in your group.

The game is similar to the one played in the first part. The only difference is that the 100 token prize, if offered, ($X \geq 100$), is now won by the member of your group who contributes the *most* tokens toward winning the prize. If there is a tie, then one of the group members contributing the most tokens toward winning the prize will be randomly selected and awarded the 100 token prize. Thus, unlike the first part, it is no longer the case that any group member who contributes more than 0 tokens has some chance of winning the prize; now *the winner is the group member who contributes the most tokens toward winning the prize.* Notice that the more tokens you contribute the greater is your chance of winning the 100 token prize.

Every other aspect of the decision-making game is the same as before.

Specifically, on the decision screen for each round you are asked: How many of your 400 tokens would you like to contribute? In the input box, type in the number of tokens you want to contribute, any number between 0 and 400, inclusive. You can change your mind anytime prior to clicking the OK button. When you are satisfied with your choice, click the OK button

After all participants have clicked the OK button, the computer program will calculate the total number of tokens that all members of your group of size 10 (including you) have contributed. Let us call this number X.

If $X<100$, then the 100 token prize is not awarded to any member of your group. Each group member gets back any of his/her 400 tokens contributed toward winning the prize. Earnings for the round are 400 tokens for each subject.

If $X \geq 100$, then the 100 token prize is won by the member of your group who contributed the most tokens toward winning the prize. If there is a tie, then one of the group members contributing the most tokens toward winning the prize will be randomly selected and awarded the 100 token prize. The more tokens you contribute, the greater is your chance of winning the 100 token prize. Tokens that you do not contribute toward winning the 100 token prize remain in your "private" account.

If $X \geq 100$, then the amount X-100 of tokens will be placed in a "group" account. All 10 members of your group, even those who did not contribute any tokens toward winning the 100 token prize will earn additional tokens based on the number of tokens in the group account.

Specifically, if $X \geq 100$, each member of your 10-person group will earn $.75 \times (X-100)$ tokens. These tokens are in addition to the tokens that remain in your private account or the 100 token prize awarded to the winner. The table below gives you a non-exhaustive list of your possible earnings from the group account.

If X Is	then (X-100) is	and the Tokens Earned by Each Member of the Group is
100	0	0
150	50	37.5
200	100	75
250	150	112.5
300	200	150
350	250	187.5
400	300	225
450	350	262.5
500	400	300
1000	900	675
1500	1400	1050
2000	1900	1425
2500	2400	1800
3000	2900	2175
3500	3400	2550
4000	3900	2925

If X<100, no tokens are placed in the group account.

Total Earnings

Your total tokens for each round are the sum of three items.

1. The number of tokens that remain in your private account. If X<100, the number of tokens in your private account will be set equal to your endowment of 400 tokens. Otherwise, if X≥100, the number of tokens in your private account is 400-c, where c is the number of tokens that *you* contributed toward winning the 100 token prize.
2. If X≥100, AND you win are the prize winner, then you receive an additional 100 token prize for that round.
3. If X≥100, you and every other member of your group earns an additional .75 ×(X-100) tokens based on the number of tokens in the group account.

At the end of the experimental session, the computer program will randomly select two rounds: one from the first part (first 15 rounds) and one from the second part (last 15 rounds). The sum of tokens earned in these two rounds will be your total token earnings for the experiment. At the end of the experiment your total token earnings will be converted into cash earnings at the rate of 1 token = $0.005 (1/2 cent).

Feedback

At the end of each period your computer screen will report back to you:

- The number of tokens you contributed toward winning the prize, c
- The total number of tokens submitted by all members of your group including you, X.

- Whether the prize was awarded, yes (if $X \geq 100$) or no (if $X < 100$).
- If $X \geq 100$, the number of tokens offered by the winner of the prize.
- If $X > 100$, whether you won or lost the 100 token prize.

You will also be shown the calculation of your total token earnings for the round. Specifically, you will learn:

1. The number of tokens that remain in your private account.

If $X \geq 100$, you will also learn:

2. Prize tokens: 100 if you won the prize, 0 otherwise.
3. The number of tokens you and the other member of your group each earn from the group account, equal to $.75 \times (X-100)$ tokens.

- Finally, you will be told your total tokens earned for the round, which is the sum of the token amounts in items 1-3 above.

Record Sheets

Please record the information reported to you on the outcome of each round on your record sheet under the appropriate headings. Be sure also to indicate on your record sheet your player ID number.

For your convenience, the history of information reported back to you at the end of each round will appear at the bottom of your first decision screen.

Questions

Are there any questions before we begin?